Montana's Approach to Developing Numeric Nutrient Standards for Wadeable Streams and Rivers

AND AN OVERVIEW OF WORK UNDERWAY FOR OTHER WATERBODIES

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Water Quality Standards Section

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Overview

- What is a Water Quality Standard?
- Numeric Nutrient Standards
  - Summary of progress
  - Scientific basis
  - Implementation policy

What is a Water Quality Standard?

It is a combination of:

1. Designated Beneficial Uses
   - Bathing, swimming & recreation
   - Drinking (human health)
   - Fish & associated aquatic life
   - Agriculture
2. Narrative statements or numbers that define level of protection (criteria)
3. Nondegradation Policy

Nutrient Standards

- Montana is developing *numeric* nutrient standards
- Nutrients (nitrogen and phosphorus) commonly cause impacts to standards Montana already has on the books (narrative & numeric)
  - "State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:……..
    (e) create conditions which produce undesirable aquatic life."
  - Dissolved oxygen concentrations (circular DEQ-7)

EPA National Strategy for Numeric Nutrient Standards

1998: "EPA expects all States and Tribes to adopt and implement numerical nutrient criteria into their water quality standards by December 31, 2003."

2001: EPA softened its expectations for states to adopt standards by 2003. Instead:

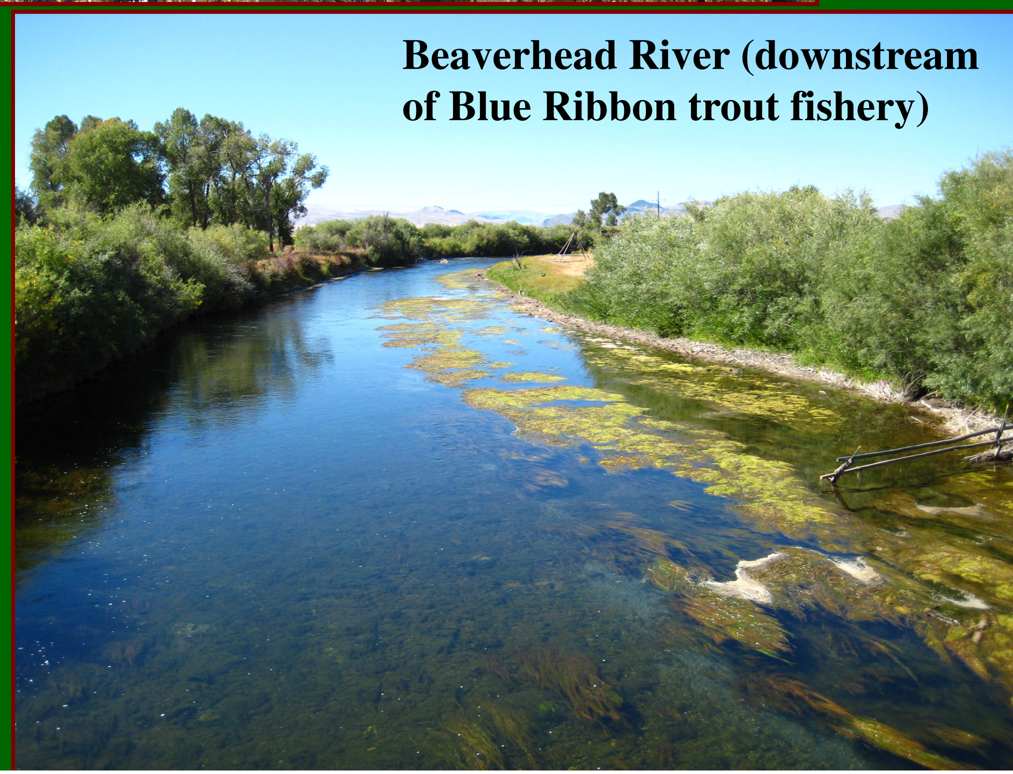
- States develop plans/schedule for nutrient standards adoption
- States conduct scientific studies at the State/regional level

- **Virtually all states now in process of development or have these in law**

Jan 14, 2009: EPA told Florida it must adopt numeric nutrient standards for all surface waters (fresh and estuarine) within 1-2 yrs

Why are Nutrient Standards Important?

1. Causes over-fertilization of aquatic habitats, resulting in adverse impact to recreation, fish & aquatic life uses
2. Nationally, nutrient enrichment ranks among the top causes of water resource impairment
    1. Clark Fork River
    2. Chesapeake Bay, Gulf of Mexico
3. Very widespread, multiple sources
4. Can affect dissolved oxygen (DO) and pH. Low oxygen levels cause fish kills, “anoxic zones”



Nuisance algal growth

Nutrient Standards — Status

- Goal: numeric nutrient standards for all surface waters
  - Narratives have been in place many years
  - Numbers in place for most of Clark Fork River since 2002
    - Total Nitrogen = 0.3 mg/L
    - Total Phosphorus = 0.02 or 0.039 mg/L
    - Algal chlorophyll *a* = 100, 150 mg/m^2

Apply in summer only

  - Wadable streams & rivers will be next (2010)
    - Basic science largely done
      - We continue to refine & improve the science
    - Currently working out implementation policy
  - Working on science to support numbers for large rivers, lakes
    - Lower Yellowstone River model nearing completion

Montana's Approach

- Science establishes the numeric criteria for surface waters

- Policy addresses the difficulties of meeting the criteria

Science: How were the Criteria Derived?

Nutrient criteria development across a large, diverse state required 3 major parts:

1) Identification of appropriate geographic zones in which specific nutrient criteria (e.g., total P, total N) would apply

2) Understanding of cause-effect (i.e., stressor-response) relationships between nutrients and beneficial uses (e.g., fisheries, recreation, aquatic life)
   - Requires determining "harm to use"

3) Water quality data from reference sites

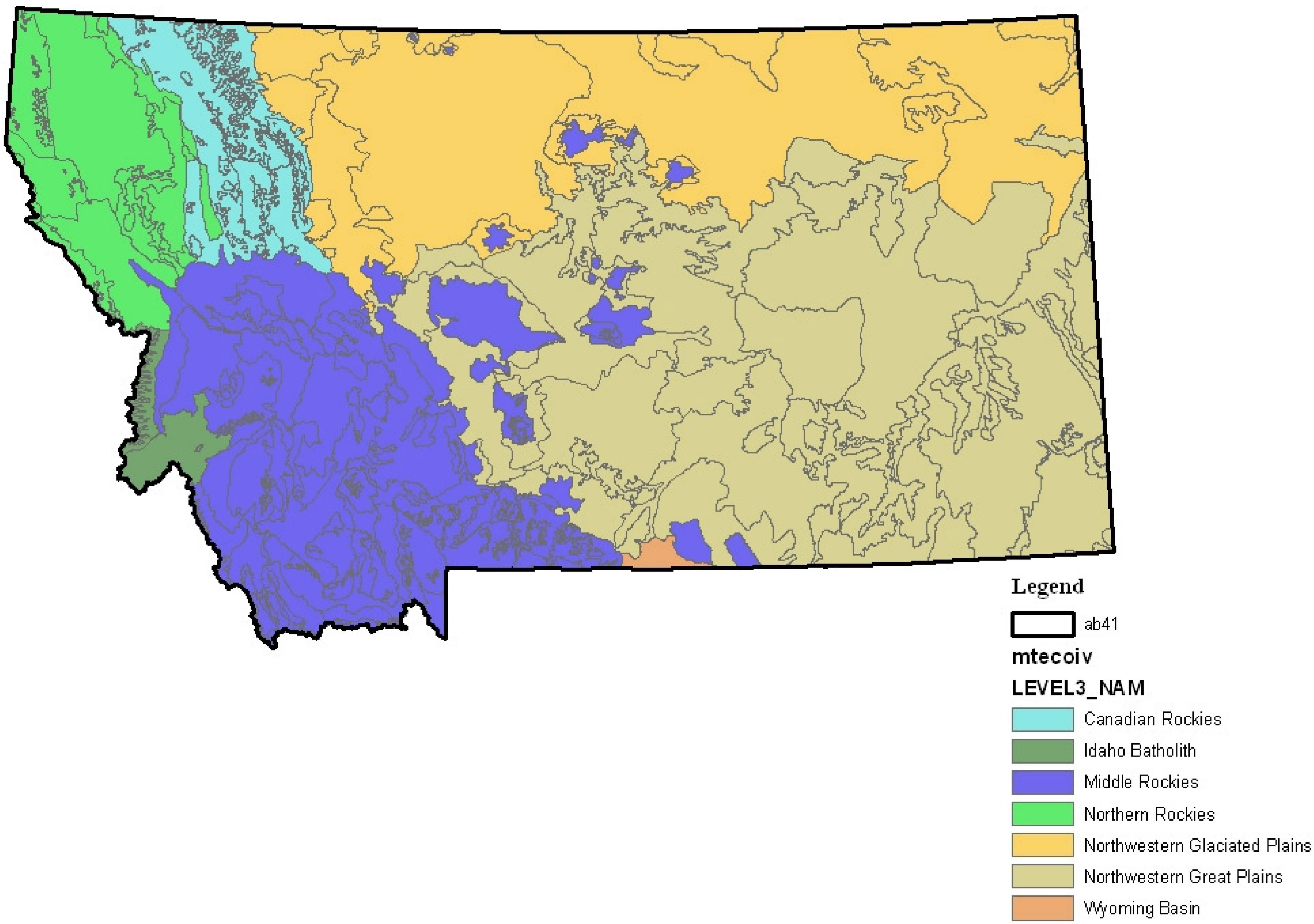
Science: (1) Identifying an Appropriate Geospatial Framework

- Nutrient concentrations vary naturally — geology, soils, climate, vegetation

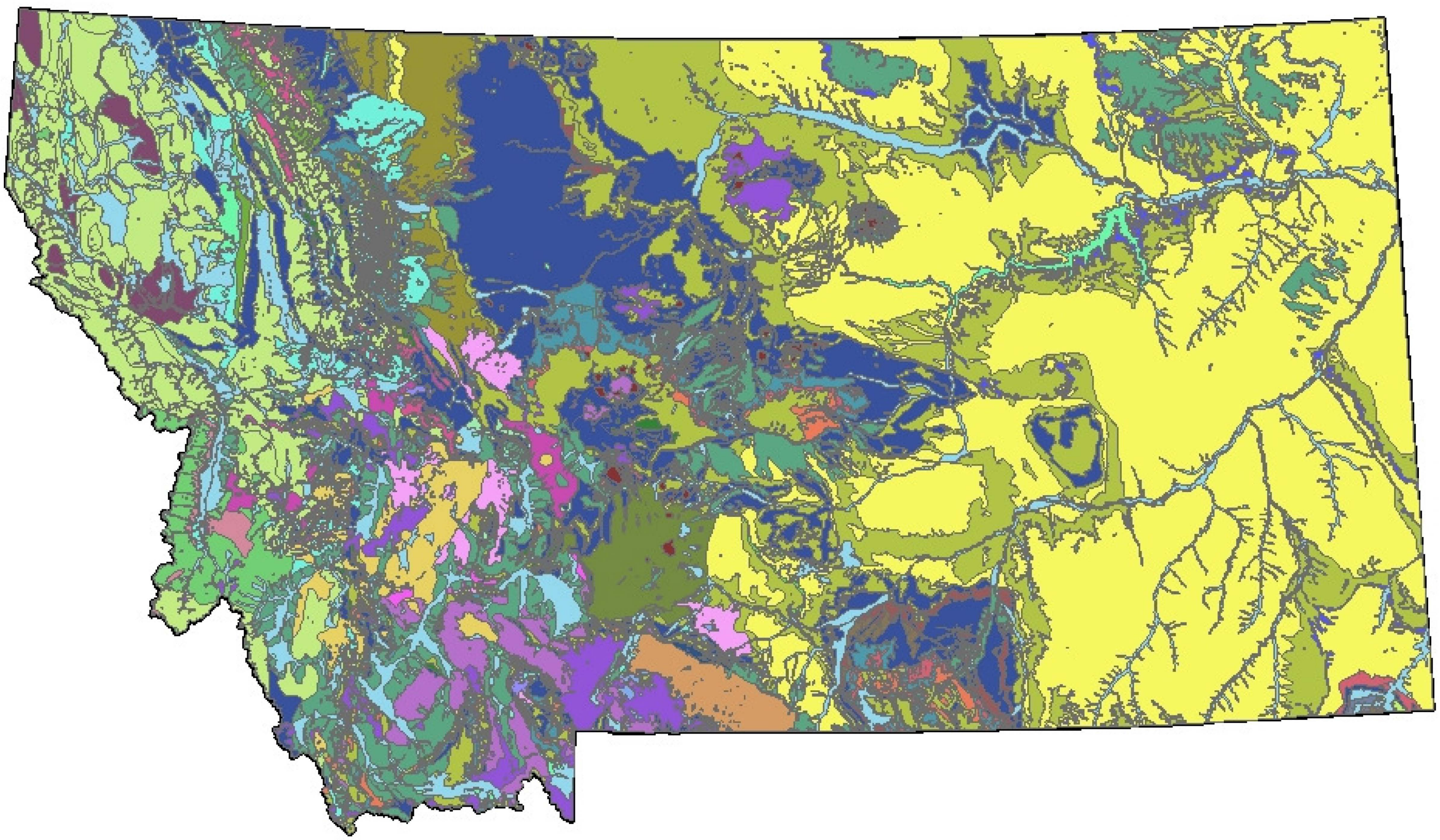
- DEQ needed a practical geospatial framework that explained a good proportion of nutrient-concentration variability in wadeable streams
  - Ecoregions (developed by Jim Omernik)
  - Lithology
  - Strahler Stream Order

- The best geospatial framework maximizes the variance between zones, & minimizes the variance within zones

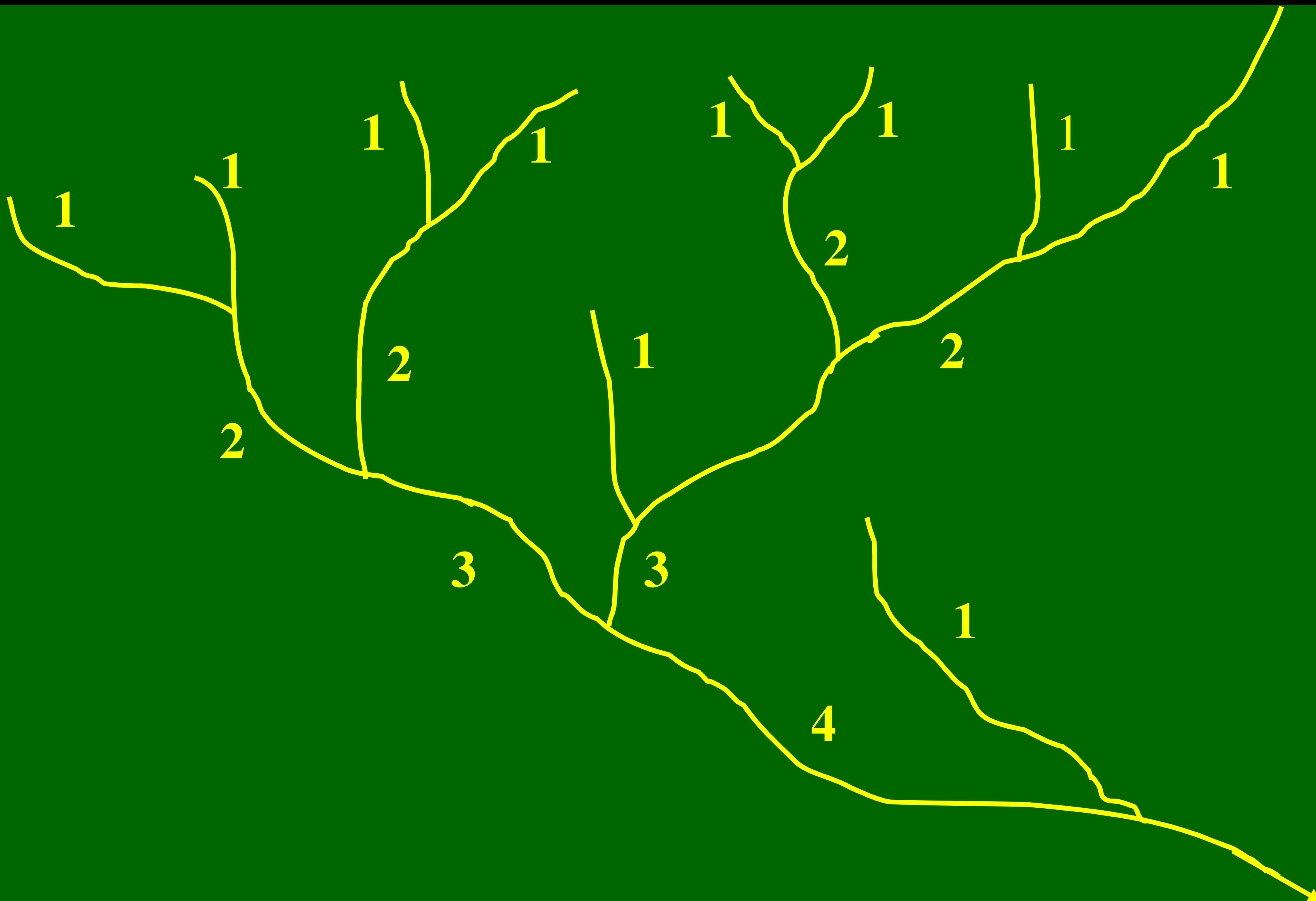
Level III Ecoregions of MT (Woods et al. 2002)



USGS Geology Map of Montana (1955)



Strahler Stream Order



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Science: (1) Conclusions about the Geospatial Frameworks

- Level III & IV ecoregions worked better than lithology and stream order, in terms of explaining variation in nutrient concentrations and in practicality of application

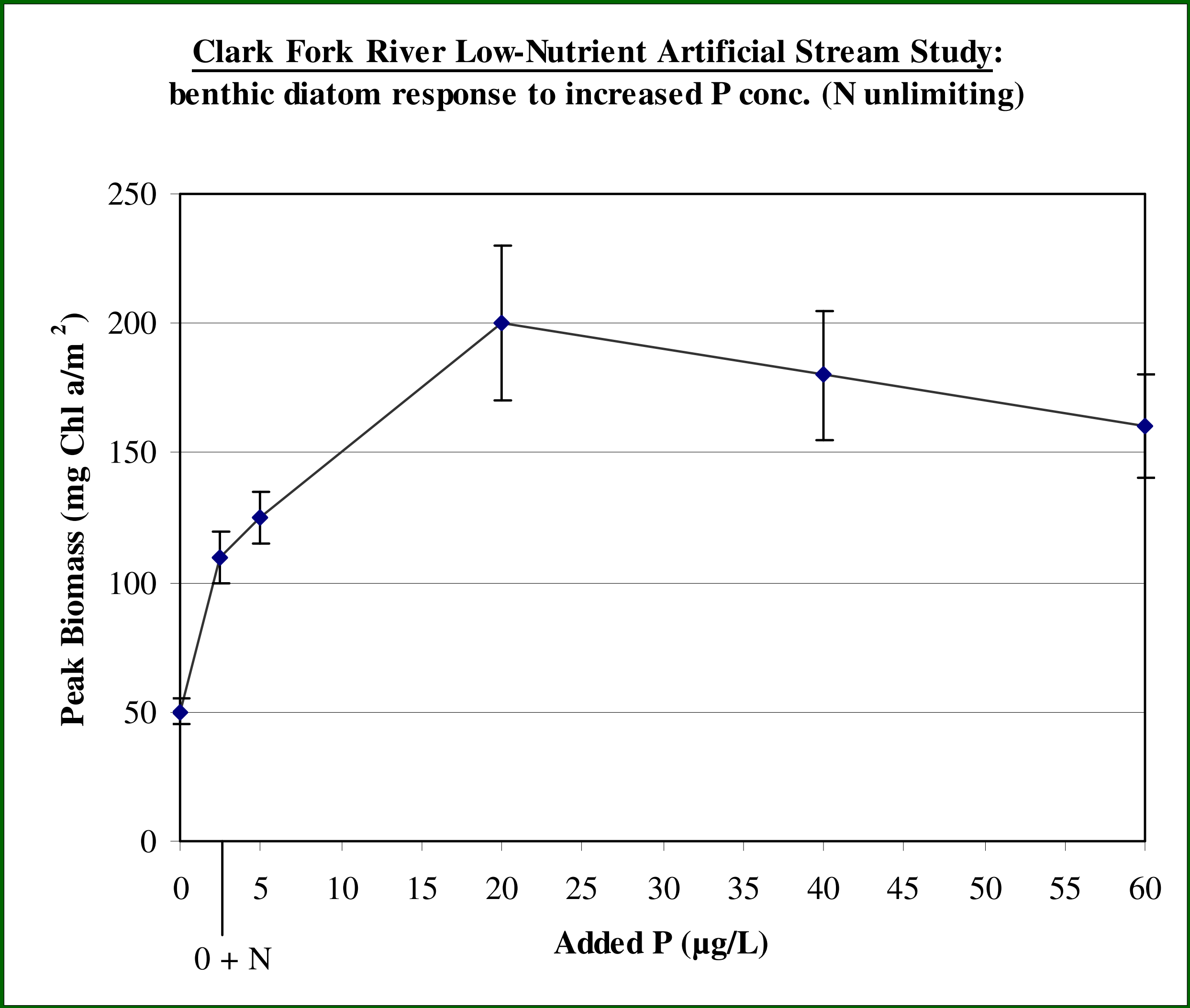
- Ecoregions explained enough spatial variability in nutrients that they may be used as a basis to establish criteria in Montana

Science: *(2) Stressor-response, Harm-to-use*

- Stressor-response studies (e.g., TN *vs.* dissolved oxygen concentrations)

- Harm-to-use thresholds: Identifying the point where nutrient concentrations begin to impact sensitive beneficial uses
  - *Recreation* (nuisance algae public-opinion survey)
  - *Fish & aquatic life*

Science: (2) Example Stressor-response Study



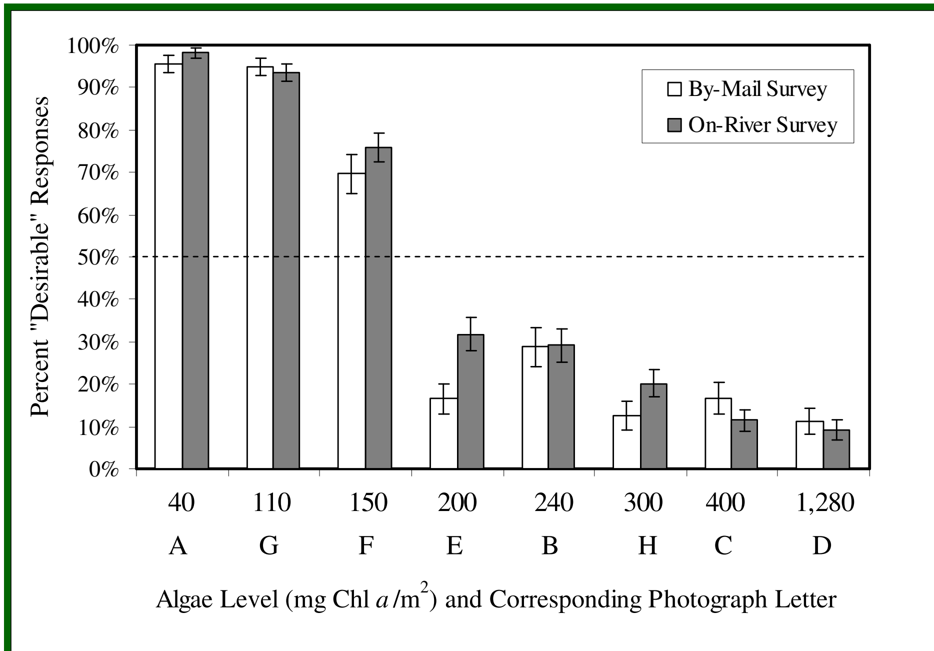
Redrawn from Watson (1990)

DEQ has reviewed artificial stream, whole-stream fertilization, and correlative studies in determining the criteria

Science: (2) Harm-to-Use: Recreation

Criteria are designed to protect against nuisance algal growth e.g. our narrative states…

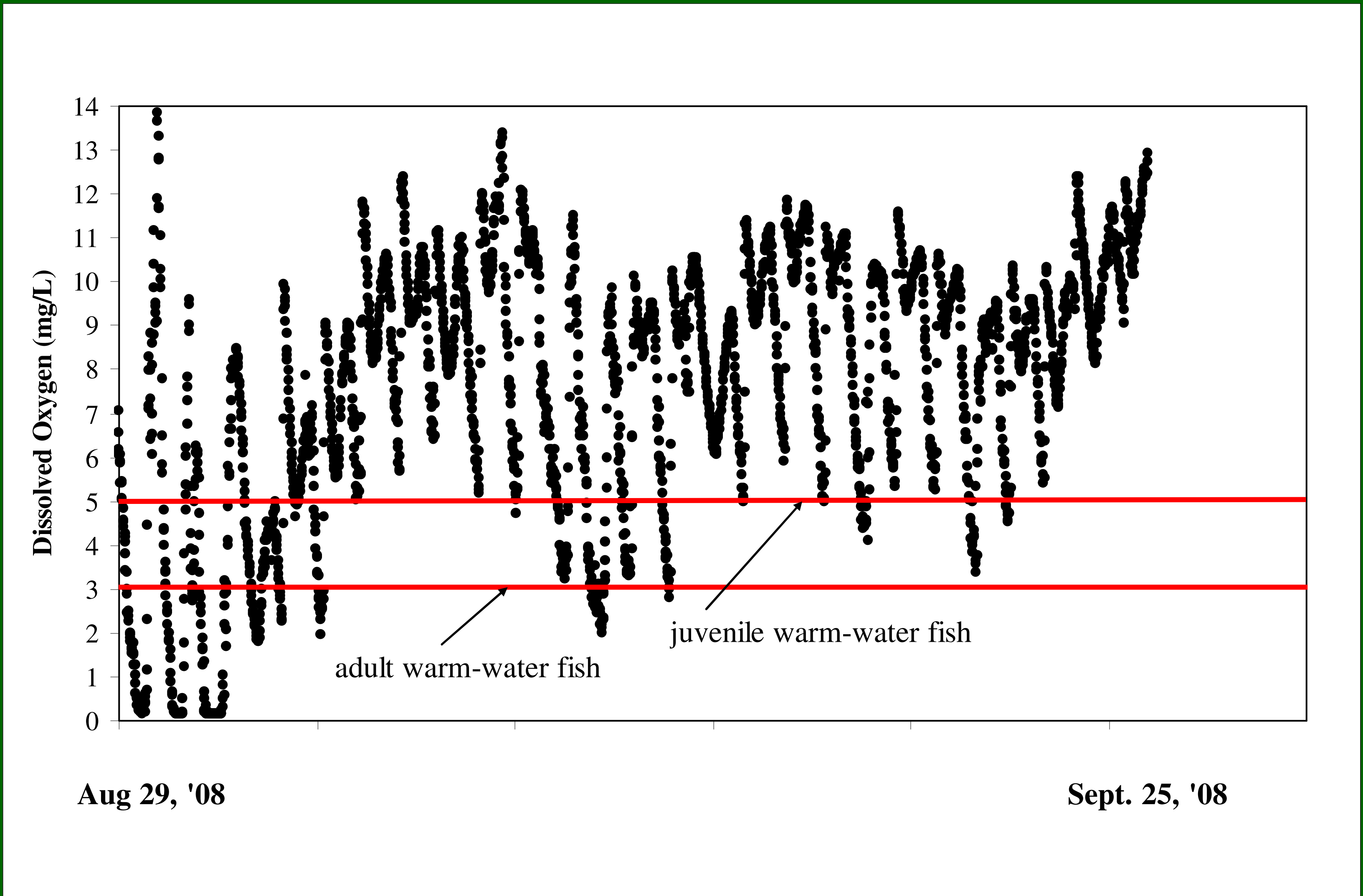
"State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will create conditions which produce undesirable aquatic life" (ARM 17.30.637[1][e]).



<u>Science</u>: (2) Harm to Use: Recreation Threshold

<u>Suplee, Watson, Teply & McKee, 2009.</u> How Green is too Green? Public Opinion of what Constitutes Undesirable Algae Levels in Streams. *Journal of the American Water Resources Association* **43**: 123-140.

<u>Science</u>: (2) Harm-to-Use: Aquatic Life Thresholds



In eastern MT prairie streams, nutrient criteria are being set to maintain dissolved oxygen levels at state standards (fish, aquatic life)

Science: (2) Stressor-response, Harm-to-use – Ongoing Wadeable Stream Work

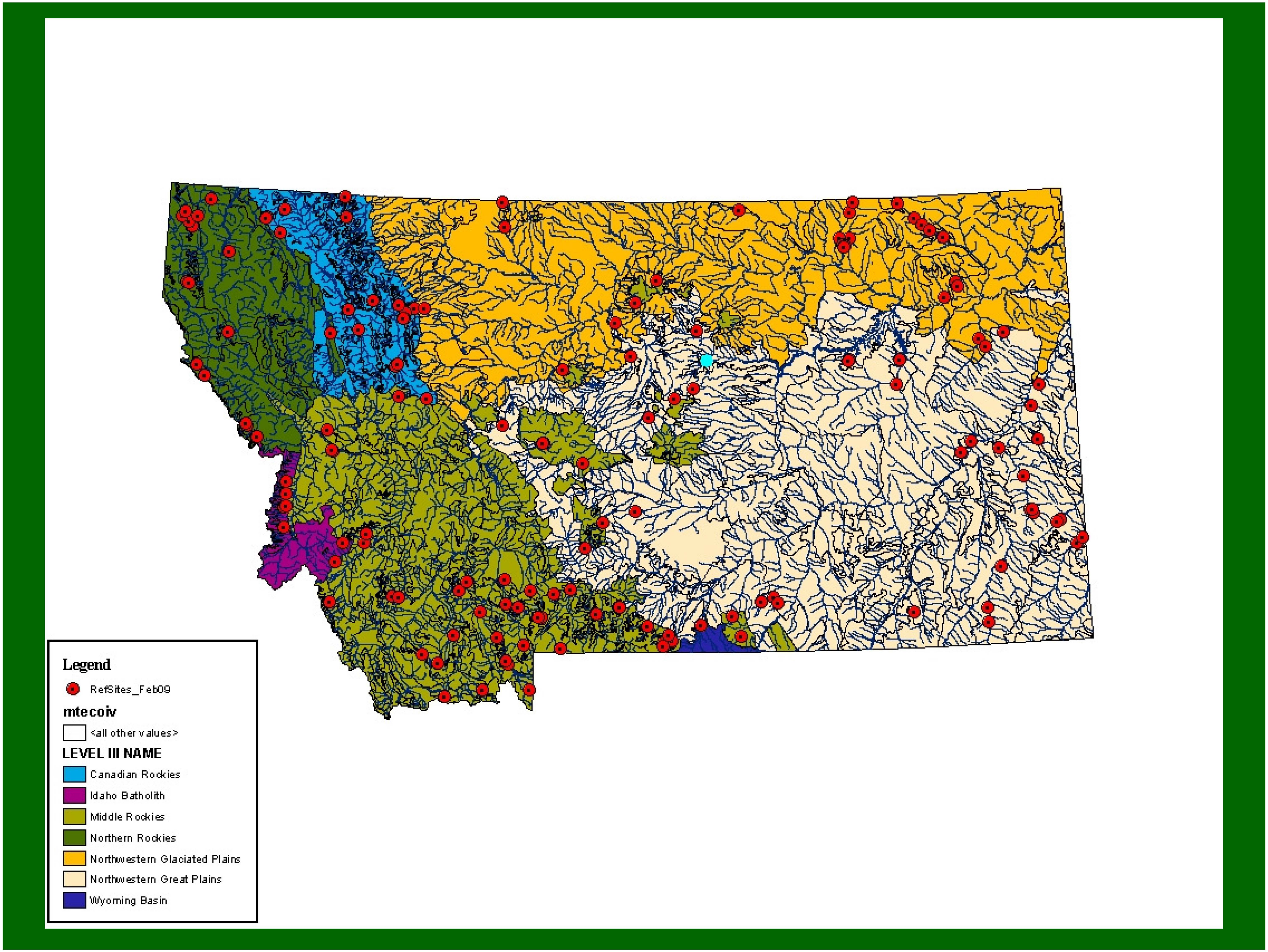
- DEQ & EPA are carrying out a large-scale analysis of the relationship between macroinvertebrates (aquatic insects) and stream nutrients across Montana
  - Change points (thresholds) in macroinvertebrate populations useful for helping cross check criteria derived by other means
- DEQ is planning a whole-stream fertilization study for two eastern MT prairie streams (2009-2011)
  - Will provide more solid understanding of nutrient affects in these complex, intermittent stream systems

Science: (3) Reference Stream Sites

Reference Streams: Nutrient concentration data from reference streams — which don't have nuisance algae or low dissolved-oxygen problems — were compiled for each ecoregion

Western MT reference stream site

Eastern MT prairie-stream reference site



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LEVEL III NAME
Canadian Rockies
Idaho Batholith
Middle Rockies
Northern Rockies
Northwestern Glaciated Plains
Northwestern Great Plains
Wyoming Basin

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<u>Science</u>: Comparing Stressor-response Study Results to Reference Data - Why do it?

- Individual stressor-response studies are geographically limited, and each has its own statistical uncertainties

- Individually, each stressor-response study is suggestive; collectively, they become far more conclusive
  - Akin to a "strength-of-evidence" approach
  - Comparing results from a regional stressor-response study to reference data from its corresponding ecoregion provides a means to tie various studies together

- Helps assures that criteria for any region are not overly stringent or insufficiently protective

Science: Linking Stressor-response Studies & Reference Data

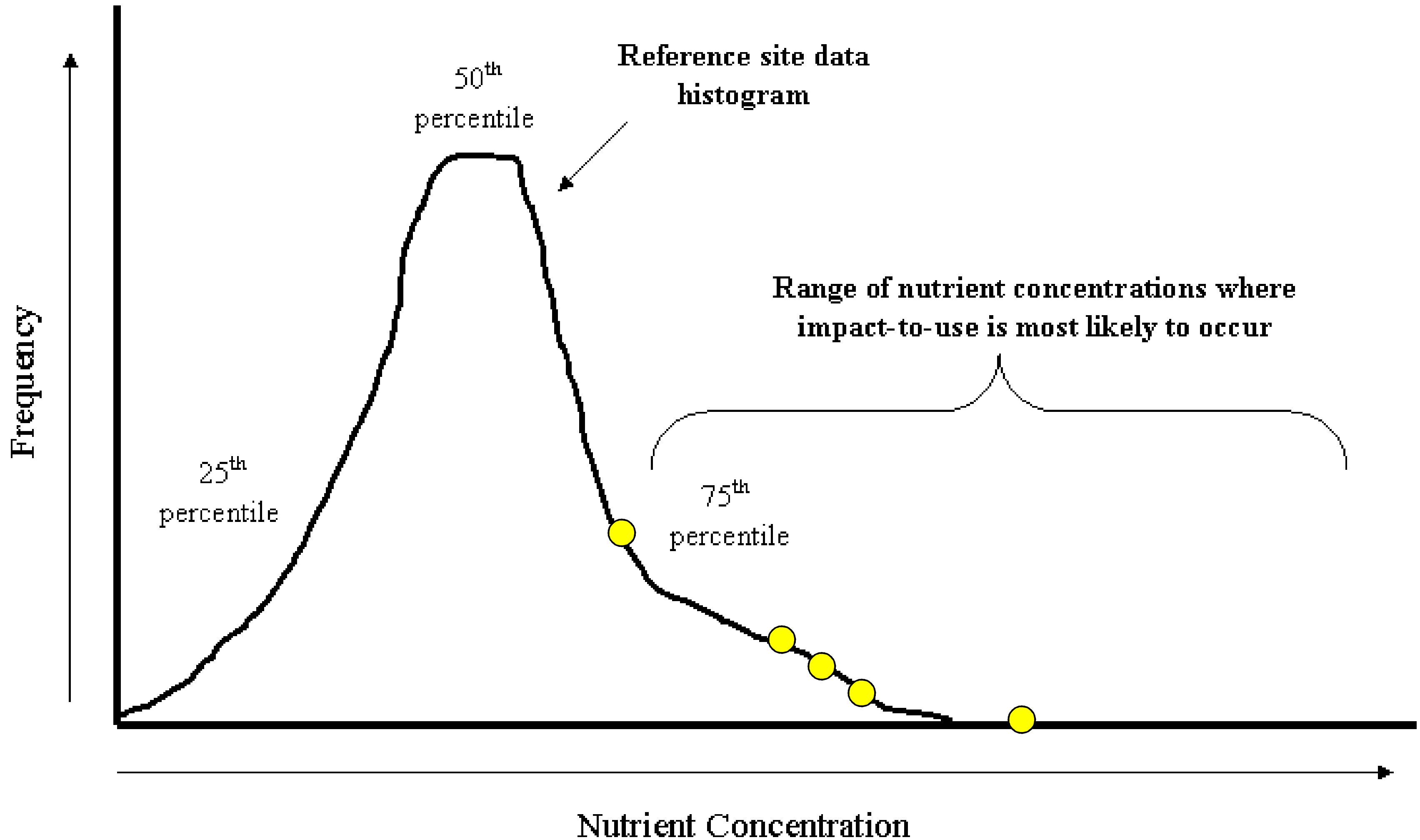


Figure 6.2. Conceptual Diagram Showing a Nutrient Concentration Histogram for Reference Sites. The figure shows where along the x-axis, relative to the histogram, nutrient concentrations likely to impact beneficial water uses would be expected to be found.

Science: Linking Stressor-response Studies & Reference Data

Stressor-response Study	Nutrient	Stressor-response Study Nutrient Concentration (mg/L)	Season of Application	**Level III Ecoregion**	# Samples in During Summer Growing Season	**Percentile in Reference Distribution Matching Stressor-response Study Concentration**	Sensitive Benefical Use Nutrient Concentration Applies To:
			Reference Stream Sites				
Welch *et al*. (1989)	SRP	0.01	Growing (summer)	**Northern Rockies**	75	**94th**	Recreation
Watson *et al.* (1990)	SRP	0.011	Growing (summer)	**Middle Rockies**	211	**87th**	Recreation
Sosiak, A. (2002)	TP	0.018	Growing (summer)	**Canadian Rockies**	68	**97th**	Recreation
Bowman *et al.* (2007)	SRP	0.009	Growing (summer)	**Canadian Rockies**	59	**108th***	Recreation
Suplee *et al*. (2008) Technical Document (Appendix A)	TN	1.12	Growing (summer)	**Northwestern Glaciated Plains**	59	**70th**	Fish & Aquatic Life
					Mean:	**91**	
					Median:	**94**	
					CV (%):	**15**	

* Interpolated from dataset.

Also see Suplee, M.W., Varghese, A., and J. Cleland, 2007. Developing Nutrient Criteria for Streams: An Evaluation of the Frequency Distribution Method. *Journal of the American Water Resources Association* 43: 453-472.

Science: *Montana's Draft Criteria*

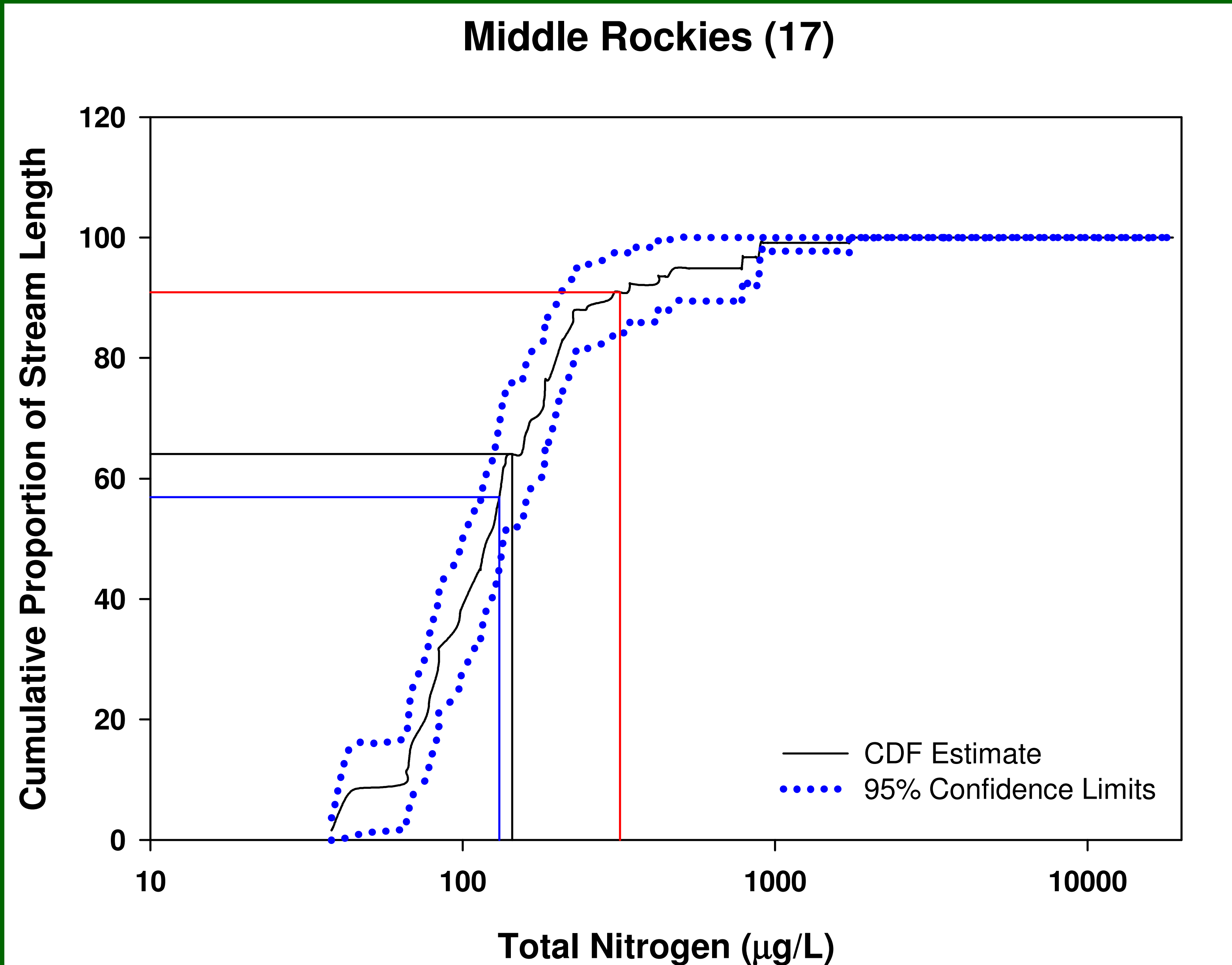
Criteria are seasonal only. In addition to N and P, benthic algae criteria are suggested for the western mountainous ecoregions

Ecoregion	Period When Criteria Apply	Nutrient Criteria: Reference Percentile Criteria Are Linked to	Nutrient Criteria: TP (mg/L)	Nutrient Criteria: TN (mg/L)	Nutrient Criteria: NO_{2+3} (mg/L)	Benthic Algae Criteria
Level III Ecoregions						
Northern Rockies	July 1 -Sept. 30	90th	0.012	0.233	0.081	150 mg Chl *a* /m^2 (36 g AFDW/m^2)
Canadian Rockies	July 1 -Sept. 30	90th	0.006	0.209	0.020	150 mg Chl *a* /m^2 (36 g AFDW/m^2)
Middle Rockies	July 1 -Sept. 30	90th	0.048	0.320	0.100	150 mg Chl *a* /m^2 (36 g AFDW/m^2)
Idaho Batholith	July 1 -Sept. 30	90th	0.011	0.130	0.049	150 mg Chl *a* /m^2 (36 g AFDW/m^2)
Northwestern Glaciated Plains	June 16-Sept. 30	75th	0.123	1.311	0.020	n/a
Northwestern Great Plains	July 1 -Sept. 30	75th	0.124	1.358	0.076	n/a

Science: Comparison of Some of Montana's Criteria To Other Studies/Criteria in Temperate Streams

Source	Location	Concentration Shown Would:	Nutrient (mg/L) Total N	Total P
***Draft* DEQ Values**	**Middle Rockies Ecoregion, Montana**	**Prevent nuisance algal growth**	**0.320**	**0.048**
Perrin *et al.* (1987)	British Columbia, Canada	Prevent nuisance algal growth	0.4	0.02
Miltner & Rankin (1998)	Ohio	Protect fish communuties	n/a	0.06
Chételat *et al.* (1999)	Ontario & Quebec, Canada	Prevent nuisance algal growth	n/a	0.04 to 0.07
Wang *et al.* (2007)	Wisconsin	Protect fish and macroinvertebrate communities	0.99	0.073
Dodds *et al.* (2006)	North American, Austrailian, New Zealand and European temperate streams	Prevent nuisance algal growth	0.578	0.080
ANZECC & ARMCANZ Trigger Values (2000)	New Zealand (upland rivers)	Prevent nuisance algal growth & cyanobacterial blooms	0.295	0.026
ANZECC & ARMCANZ Trigger Values (2000)	Australia (upland rivers)	Prevent nuisance algal growth & cyanobacterial blooms	0.250	0.02

Analyses Indicate Most Montana Streams Already Meet the Criteria



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Work on Other Waterbody Types

- Lakes: DEQ collecting data (water quality, bathymetry, shoreline assessment) primarily in western Montana lakes since 2003
  - Data compilation phase (DEQ-collected and historic) in progress, ready 7/09
  - Next step: identify lake zoning procedure (map system) that lumps lakes of a similar nature together
- Large Rivers: Pilot effort on lower Yellowstone River using a water quality model (QUAL2K) nearing completion
  - DEQ working directly with model developer (Dr. S. Chapra) in model development and refinement
  - With Dr. Chapra, DEQ has advanced the model by creating a module that simulates algal growth along river transects (right to left bank)
  - All indications suggest that the model will reasonably simulate the river and that DEQ will be able to estimate nutrient criteria from the model

What if the Criteria Cannot, Ultimately, be Met?

- EPA has indicated 20 years is reasonable to determine if a water quality problem is temporary and correctable
- Options would then include:
  - Renew variance
  - Carry out a Use Attainability Analysis, create site-specific criteria and downgrade uses (e.g., marginal recreational use) on some streams

Summary of Key Points

- Water quality standards are set to protect instream beneficial uses — sensitive use sets the bar
- Numeric nutrient standards will be different in different areas of the state (N and P)
- Numeric nutrient standards will only apply for about 3 months each year (i.e., summer)
- DEQ is committed to refinement and improvement of the wadeable stream criteria, and is working on lake and large river criteria as well

Thank You.
Questions?

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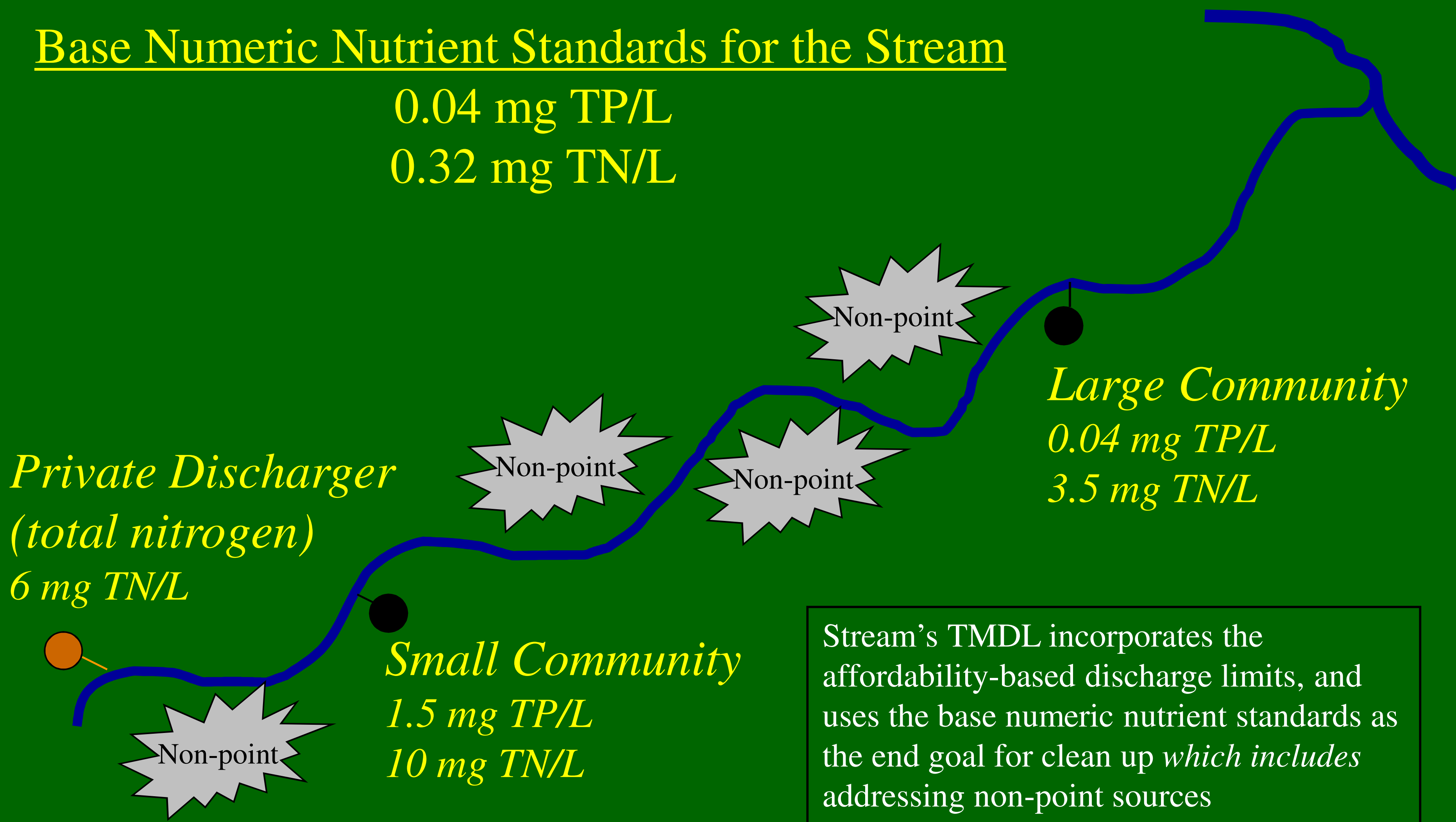
How This Approach Might Look Along a Stream

Base Numeric Nutrient Standards for the Stream

0.04 mg TP/L

0.32 mg TN/L



Stream's TMDL incorporates the affordability-based discharge limits, and uses the base numeric nutrient standards as the end goal for clean up *which includes* addressing non-point sources